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Author manuscript

*J Pediatr.* Author manuscript; available in PMC 2017 September 01.

Published in final edited form as:

*J Pediatr.* 2016 September ; 176: 121–127.e1. doi:10.1016/j.jpeds.2016.05.037.

## Sex differences in cardiometabolic risk factors among Hispanic/Latino Youth

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### Abstract

**Objective**—To determine the prevalence of obesity and cardiometabolic risk in US Hispanic/Latino youth and examine whether there are disparities by sex in cardiometabolic risk factors.

**Study design**—SOL Youth is a population-based cross-sectional study of 1466 Hispanic/Latino youth (8-16 years old) who were recruited from four urban US communities (Bronx, NY; Chicago, IL, Miami, FL, and San Diego, CA) in 2012-2014. The majority of children were US-born (78%) and from low-income and immigrant families. Cardiometabolic risk factors were defined using national age- and sex-specific guidelines.

**Results**—The prevalence of obesity was 26.5%. The prevalence of class II-III obesity, diabetes and dyslipidemia was high (9.7%, 16.5%, and 23.3%, respectively). The prevalence of cardiometabolic risk factors increased with severity of obesity in both, boys and girls. Boys had a higher prevalence of diabetes and of elevated blood pressure than girls (20.9% vs. 11.8% and 8.5%

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The authors declare no conflicts of interest.

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vs. 3.3%). In multivariable analyses, younger boys were more likely to have obesity class II-III than girls (OR = 3.59; 95% CI 1.44, 8.97). Boys were more likely to have prediabetes than girls (OR = 2.02; 95% CI 1.35, 3.02), and the association was stronger at older ages.

**Conclusions**—The prevalence of cardiometabolic risk factors was high in this sample of Hispanic youth. Boys had a more adverse cardiometabolic profile compared with girls that may put them at higher risk of diabetes and cardiovascular disease later in life. Reasons for this disparity and the long-term clinical implications remain to be elucidated.

Hispanic/Latino youth are a fast growing segment of the United States (US) population, and make up 22% of all children under the age of 18 in the US.(1) Data from NHANES indicate that Hispanic youth have high rates of obesity (2, 3), but less is known about the burden of cardiometabolic risk factors in Hispanic/Latino children. Obesity and diabetes are leading cardiovascular risk factors among Hispanic/Latino adults, raising concerns about whether an increased risk of these conditions is also manifested at younger ages. Furthermore, although studies in adults indicate that women are at higher risk of obesity than men, among Hispanic/Latino youth these sex differences appear to be reversed, with boys more likely to be obese than girls (3, 4). However, adult men were found to have a higher prevalence of diabetes and cardiovascular risk factors than women (5, 6). Recent studies also indicate that there are sex differences in cardiometabolic risk profiles, with boys being more likely to have impaired fasting glucose than girls, but girls being more insulin resistant (7).

It is now well accepted that the process leading to atherosclerosis and other chronic conditions starts during childhood (8-11). Therefore, describing the magnitude of these risk factors in youth is important for prioritizing prevention and public health efforts. This study expands the literature on the health status of Hispanic/Latino youth by reporting on the prevalence of obesity and cardiometabolic risk factors in a community-based sample of Hispanic/Latino youth living in four major US urban areas. Because previous reports suggest that there is a higher burden of cardiometabolic risk in Hispanic young men compared with women, this study examined sex differences in the prevalence of obesity and cardiometabolic risk factors.

## METHODS

HCHS/SOL is a population-based cohort study of 16,415 Hispanic/Latino adults (ages 18-74 years) who were selected using a two-stage probability sampling design from four US communities (Chicago, IL; Miami, FL; Bronx, NY; San Diego, CA). SOL Youth is an ancillary study to HCHS/SOL that enrolled a subset of the offspring of HCHS/SOL participants from the same four field centers. Between 2012 and 2014, 6,741 households were screened via a phone call using a standardized script; the screening identified 1,777 eligible children between the ages of 8-16 years, of whom 1,466 were enrolled, achieving a participation rate of 82%. Of these 1,466 children, 156 were excluded because they did not have values for one or more cardiometabolic factors or key covariates, leaving a final analytical sample of 1,310 for the current study. Details about the methodology and protocols of HCHS/SOL and SOL Youth are published elsewhere (12, 13). The study was conducted with approval from the institutional review boards of each of the institutions

involved in the study. Written informed consent and assent were obtained from parent/caregivers and their children, respectively.

Height (cm) was measured with a wall stadiometer (SECA 222, Germany) and weight (kg) was obtained with a digital scale (Tanita Body Composition Analyzer, TBF 300, Japan). CDC guidelines were used to classify children into categories of underweight/normal weight (BMI <85<sup>th</sup> percentile), overweight (BMI 85<sup>th</sup> to <95<sup>th</sup> percentile), or obese (BMI ≥95<sup>th</sup> percentile) (14). Obese children were further classified by the severity of obesity using recommended pediatric thresholds (4, 15). Class I obesity was defined as ≥95<sup>th</sup> percentile to <120% of the 95<sup>th</sup> percentile, class II obesity as ≥120% of the 95<sup>th</sup> percentile to <140% of the 95<sup>th</sup> percentile or BMI ≥35 to <40 kg/m<sup>2</sup>, and class III obesity (≥140% of the 95<sup>th</sup> percentile OR BMI ≥40 kg/m<sup>2</sup>). Class II and III were combined to achieve adequate sample size for analyses. Seated blood pressure was measured after 5 minutes of rest using an OMRON HEM-907XL sphygmomanometer. Three consecutive measures were obtained and the average of the last two measures was used in the analyses. Age-, sex-, and height-specific systolic and diastolic blood pressure (SBP and DBP) percentiles were derived according to established guidelines (16). Elevated blood pressure was defined as having systolic or diastolic blood pressure ≥90<sup>th</sup> percentile.

Fasting plasma glucose was measured using a hexokinase enzymatic method (Roche Diagnostics). Hemoglobin A1c (HbA1c) was measured from whole blood using a Tosoh G7 Automated HPLC Analyzer (Tosoh Bioscience Inc, South San Francisco, CA 94080). Pre-diabetes/diabetes was defined as having fasting glucose ≥100 mg/dL or HbA1c ≥5.7%, according to the American Diabetes Association guidelines (17).

Blood for lipid assays were obtained under fasting conditions. Total serum cholesterol (TC) was measured using a cholesterol oxidase enzymatic method (Roche Diagnostics, Indianapolis, IN 46250), serum triglycerides using a glycerol blanking enzymatic method (Roche Diagnostics, Indianapolis, IN 46250), and high-density lipoprotein cholesterol (HDL-c) with a direct magnesium/dextran sulfate method. Low-density lipoprotein cholesterol (LDL-c) was calculated using the Friedewald equation. Non-HDL cholesterol was calculated as the difference between total cholesterol (TC) and HDL-c. Cutoffs values for each lipid were chosen based on the Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents (18). In addition, a TG/HDL-c ratio ≥2.2 was used because this cutoff has been related to higher cardiometabolic risk in youth (19). Lastly, dyslipidemia was defined as having total cholesterol ≥200 mg/dL, LDL-c ≥130 mg/dL; triglycerides ≥100 mg/dL for 8-9 year-old and ≥130 mg/dL for 10-16 year-old; or HDL-c <40 mg/dL.

An index of overall cardiometabolic risk was calculated by summing the presence of the following eight risk factors: obesity (BMI ≥95<sup>th</sup> percentile); SBP or DBP ≥90<sup>th</sup> percentile; fasting glucose ≥100 mg/dL; HbA1c ≥5.7%; total cholesterol ≥200 mg/dL; LDL-c ≥130 mg/dL; triglycerides ≥100 mg/dL for 8-9 year-old and ≥130 mg/dL for 10-16 year-old; or HDL-c <40 mg/dL. We then categorized participants as having 0, 1-2, or ≥3 cardiovascular disease risk (CVD) risk factors.

The pubertal development scale (PDS) consists of 5 questions for boys concerning changes in body hair, voice, skin, growth spurt, and facial hair, and for girls questions about body hair, breast change, skin change, growth spurt, and menarche (20, 21).

Children and their parents/caregivers reported their Hispanic/Latino background (Central American, Cuban, Dominican, Mexican, Puerto Rican, South American, and other/mixed), place of birth, date of birth and sex. Parents/caregivers reported their household income and their educational attainment.

### Statistical analyses

We calculated the weighted proportion of participants who had cardiometabolic risk factors overall and by sex. Test for linear trend was assessed using logistic regression with the binary variable for the CVD risk factor as the dependent variable, and weight category as the independent variable. Multivariable logistic regression was used to assess the association of sex (boys versus girls) with the presence of cardiometabolic risk factors. Multinomial logistical regression was used for outcomes that were not binary (weight category and CVD risk factors). Models adjusted for age, nativity, household income, parental education, and field center. Model 2 adjusted for all variables included in Model 1, plus percentile BMI in analyses that did not include obesity as the outcome variable. Analyses were presented for the overall sample; stratified by age group and by weight category. Sensitivity analysis included adjusting the multivariable models for Tanner stage of development in the subset of participants who had this variable available (N=898). All analyses were conducted with Stata version 14.0 (StataCorp, College Station, Texas, USA) and accounted for the complex survey sampling design (by including stratification and cluster variables) and sampling weights.

## RESULTS

The sample included 380 children living in the Bronx, 304 in Chicago, 245 in Miami, and 381 in San Diego. About half of the children in the target population were boys (51.4%) and a little over half (52.7%) were between the ages of 8-12 years. The majority of children were born within the 50 US states (78%) and were of immigrant parents (86% born outside the 50 US States); 49% of children were of Mexican background. The majority of children came from low income households; 53% of them reported a household income of \$20,000 and 38% of their parents reported less than a high school education. Characteristics of the study target population are presented in Table I.

### Prevalence of obesity and cardiometabolic risk factors

The overall prevalence of overweight and obesity was 19.9% and 26.5%, respectively. The prevalence of overweight did not vary significantly by sex, but boys had a slightly higher prevalence of obesity than girls (28.4% vs. 24.6%) (Table II). The overall prevalence of obesity class II/III was 9.7% (CI: 7.1%, 12.1%), with boys having a slightly higher prevalence than girls (10.2%, CI: 7.6, 13.6; and 9.2%, CI: 6.5-12.8, respectively). Overall, the prevalence rates of prediabetes and dyslipidemia were high (16.5%, and 19.9%, respectively) (Table II). Boys had a higher prevalence of pre-diabetes compared with girls

(20.9% vs. 11.8%, respectively). Boys had almost three times the prevalence of elevated blood pressure, compared with girls, but the confidence intervals overlapped. The prevalence of dyslipidemia and individual lipid factors were similar in both sexes. About a one-half of the target population did not have any cardiovascular risk factors (Table II), with more girls being free of cardiovascular disease risk factors.

### **Obesity and cardiovascular disease risk factors**

As expected, there was an increasing linear trend in number of cardiovascular disease risk factors across categories of weight, for both boys and girls (Figure). Notably, the prevalence of pre-diabetes among children with obesity class II/III was high (26%, CI: 18.1, 35.7), particularly among boys (31.4%, CI: 20.3, 45.2). Furthermore, more than 50% of boys and girls with class II/III obesity had dyslipidemia.

### **Sex differences in obesity and cardiovascular disease risk factors**

Overall, the odds of obesity were similar in boys and girls (OR=1.25; 95% CI 0.87, 1.80). However, among children 8-10 years old, there was a higher odds of obesity in boys compared with girls (OR=2.14; 95% CI 1.14, 4.02) that was not observed in other age groups. Furthermore, boys 8-10 were almost four times more likely to have class II/III obesity, compared with girls (Table III). Boys had twice the odds of having pre-diabetes compared with girls (OR=2.02; 95% CI 1.35, 3.02), and this association was stronger at older ages. Boys aged 13-14 had higher odds of dyslipidemia than girls, but this association was not present in other age groups. When looking at individual lipid factors, there were no sex differences, except for high TG/HDL ration among 13-14 year old boys. Regarding blood pressure, boys were almost three times more likely than girls to have elevated blood pressure, but due to the low prevalence we could not estimate whether this association was consistent across all age groups. This disparity was not statistically significant when examining systolic or diastolic blood pressure separately. Furthermore, the presence of elevated number of cardiovascular disease risk factors (≥ 3) was similar in boys and girls and consistent across age groups. However, boys were more likely than girls to have a moderate number of cardiovascular disease risk factors (1-2), and this association was stronger among 13-14 year old boys.

Tanner stage was derived, using the Pubertal Development Scale, in 69% of the sample (N = 898). Of these, 13.6% had a Tanner Stage I-II, 39.6% had a Tanner Stage III-IV, and 46.8% reached Tanner Stage V. A comparison between those with Tanner stage and those without showed that these groups were similar in sex and BMI percentile, but those missing pubertal development stage were younger than those with that information (mean age 10.9 vs. 12.3, respectively). The associations above remained after adjustment for reported pubertal development (Table V; available at [www.jpeds.com](http://www.jpeds.com)). We also examined whether disparities in cardiometabolic risk factors by sex were consistent across weight categories (Table IV). Interestingly, higher odds of pre-diabetes and moderate number of cardiovascular disease risk factors (1-2) in boys were only observed among the normal weight category.

## DISCUSSION

In this community-based study of Hispanic/Latino youth we observed significant sex differences in the prevalence of cardiometabolic risk factors. Younger boys were more likely to be obese than girls, but this disparity was not evident at older ages. Younger boys were more likely to have more severe levels of obesity (obesity class II/III) than girls. Notably, the study found a high prevalence of prediabetes/diabetes, with boys almost twice as likely to have pre-diabetes/diabetes compared with girls, a difference even more pronounced at older ages.

The high prevalence of severe obesity (class II/III) in this sample is also noteworthy, as it approximates rates of severe obesity in young adults (23). Consistent with prior research, the prevalence of cardiometabolic risk factors was higher in obese youth than in normal weight youth (4, 24). Furthermore, there was a strong impact of class II/III obesity on pre-diabetes and dyslipidemia. The prevalence of pre-diabetes among youth with class II/III obesity approximated rates reported for young adults (25) and dyslipidemia was found on more than 50% of class II/III obese youth. Taken together, these results highlight the need for screening and lifestyle modification interventions to promote cardiovascular health in Hispanic/Latino youth as recommended by the Integrated Guidelines for Cardiovascular Health (18). A strong focus on weight reduction and control is necessary to prevent the developing of cardiovascular disease later in life.

Sex disparities in cardiometabolic risk factors have been described by others (7, 24, 26, 27) although few studies include Hispanic/Latino children in adequate numbers to examine results by sex. A prospective study of cardiometabolic risk factors during adolescence showed an increased risk in males that was independent of adiposity (27). Another study, based on NHANES data suggested that the impact of obesity on cardiometabolic risk factors was stronger in boys compared with girls (4). A large study of Hispanic/Latino youth in California found that boys were more likely to have impaired fasting glucose, but girls were more insulin resistant (7). It's interesting to note that the adverse cardiometabolic profile in boys was observed among boys in the normal weight range and not among those with overweight or obesity. The reasons behind this cardiometabolic disadvantage observed in boys are poorly understood. Hormonal differences have been postulated as possible explanations (4, 27), as have behavioral factors such as differences in physical activity and sedentary behavior, however, no definitive conclusions have been reached (28, 29). Differences in body distribution of excess adiposity could be another explanation, as there are studies that suggest that visceral adiposity is a stronger influence on cardiometabolic abnormalities (30, 31).

The interpretation of results of this study requires caution due to some important limitations. First, the study sample is not representative of the overall Hispanic/Latino youth population in the US, but only of the communities from which the study enrolled; although these four urban communities are among the 15 metropolitan areas with the largest concentration of Hispanic/Latinos (32). The sample size does not allow us to test differences by Hispanic/Latino national background. However, the prevalence of cardiometabolic risk factors in youth of Mexican background and youth of other backgrounds, were similar (Table VI;



available at [www.jpeds.com](http://www.jpeds.com)). In adults, the HCHS/SOL study has reported important differences in cardiovascular disease risk factors (33), including diabetes, by Hispanic national background, with adults of Puerto Rican and Mexican backgrounds showing higher burden of CVD than adults from South American background. Another limitation is that oral glucose tolerance test was not available in this study, resulting in an incomplete characterization of pre-diabetes status that cannot distinguish between impairment of insulin secretion or reductions in  $\beta$ -cell function. Prior studies of pre-diabetes in youth suggest that impairment in insulin secretion plays a greater role than insulin resistance in the progression to type 2 diabetes, and having a combined phenotype of impaired glucose and impaired glucose tolerance confers an even greater risk for type 2 diabetes (34, 35). Another limitation is our measure of pubertal status, which was based on self-report and not available in all subjects. Nevertheless, in a sensitivity analysis, our associations were confirmed. Moreover, youth with pubertal assessment were not significantly different than those missing it on key demographic variables. Finally, conducting many subgroup analyses could increase the false positive rates, but sex and age comparisons were hypothesized a priori when designing the study.

Future studies need to address the longitudinal patterns of cardiometabolic risk factors to guide the identification of those most at risk of progression to type 2 diabetes and subclinical cardiovascular disease.

## Acknowledgments

Supported by the National Heart, Lung, and Blood Institute (NHLBI; R01HL102130). The children in the SOL Youth are drawn from the study of adults, the Hispanic Community Health Study/Study of Latinos, which was supported by contracts from the NHLBI to the University of North Carolina (N01-HC65233), University of Miami (N01-HC65234), Albert Einstein College of Medicine (N01-HC65235), Northwestern University (N01-HC65236), and San Diego State University (N01-HC65237). The following contribute to this study through a transfer of funds to NHLBI: National Center on Minority Health and Health Disparities, the National Institute of Deafness and Other Communications Disorders, the National Institute of Dental and Craniofacial Research, the National Institute of Diabetes and Digestive and Kidney Diseases, the National Institute of Neurological Disorders and Stroke, and the Office of Dietary Supplements. The content is solely the responsibility of the authors and does not necessarily represent the official views of the funders.

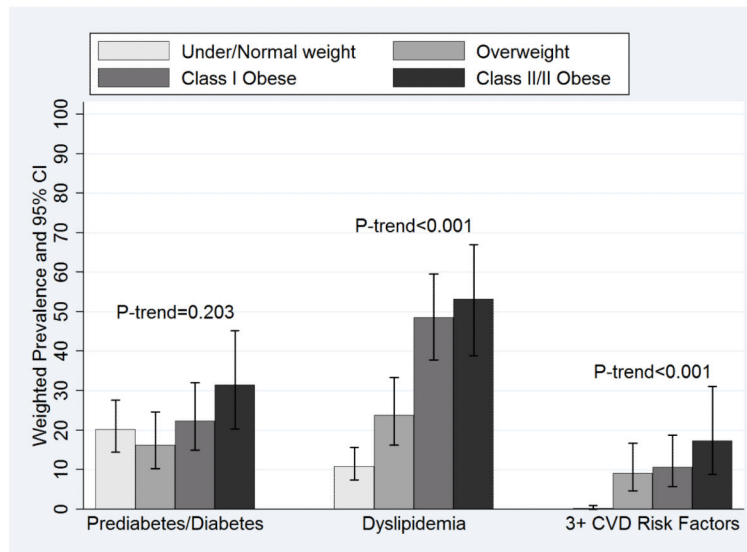
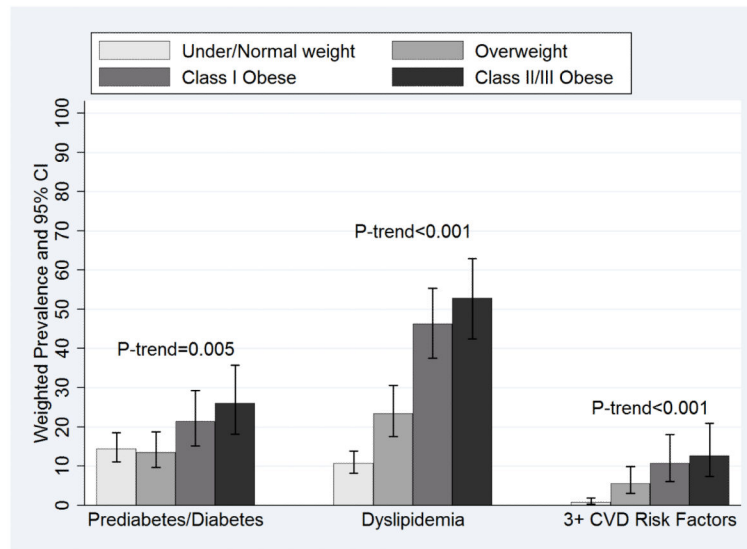
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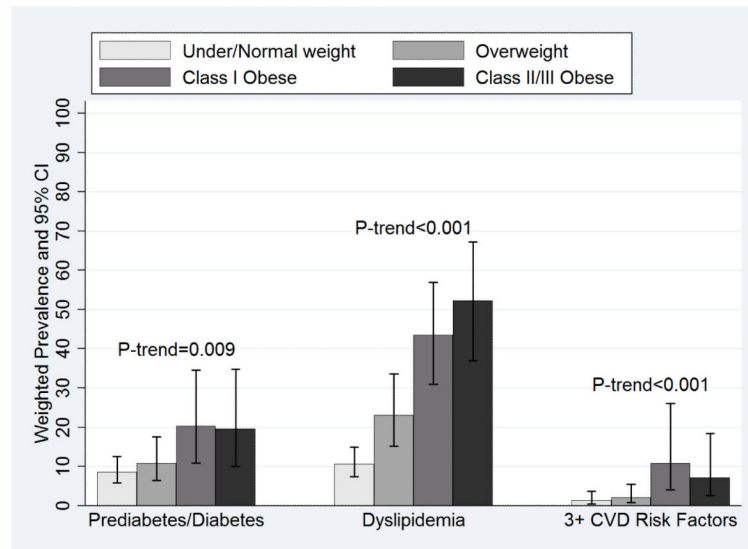
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**Figure.**  
Cardiometabolic risk by weight category in the Study of Latino Youth (SOL Youth). A, A, All, B, boys only, C, girls only.

**Table 1**

Distribution of study population characteristics. The Study of Latino Youth (SOL Youth)

	<u>Unweighted n (Weighted %)</u>
<b>Field Center</b>	
<b>Bronx</b>	380 (36.6)
<b>Chicago</b>	304 (14.2)
<b>Miami</b>	245 (14.0)
<b>San Diego</b>	381 (35.2)
<b>Age group</b>	
<b>8-10 years old</b>	417 (30.9)
<b>11-12 years old</b>	314 (21.8)
<b>13-14 years old</b>	339 (22.6)
<b>15-16 years old</b>	240 (24.8)
<b>Male</b>	653 (51.4)
<b>US-born (within 50 US states )</b>	1014 (78.2)
<b>Hispanic/Latino background</b>	
<b>Mexican</b>	586 (48.9)
<b>Dominican</b>	148 (13.5)
<b>Central American</b>	100 (6.3)
<b>Puerto Rican</b>	119 (10.5)
<b>Cuban</b>	95 (5.7)
<b>South American</b>	60 (4.2)
<b>Mixed</b>	113 (9.1)
<b>Other</b>	22 (1.9)
<b>US-born parents (within 50 US states )</b>	174 (13.9)
<b>Parental educational attainment</b>	
<b>&lt; High school</b>	502 (38.0)
<b>High school</b>	372 (29.5)
<b>&gt;High school</b>	436 (32.5)
<b>Household income</b>	
<b>\$20,000</b>	695 (53.0)
<b>\$21,000-\$40,000</b>	423 (31.7)
<b>&gt;\$40,000</b>	192 (15.3)

**Table 2**

Prevalence of cardiometabolic risk factors by sex (N = 1310). The Study of Latino Youth (SOL Youth)

	Overall (N=1,310)	Boys (N=653)	Girls (N=657)
	Weighted % (95% CI)	Weighted % (95% CI)	Weighted % (95% CI)
<b>Normal weight (BMI &lt;85<sup>th</sup> percentile)</b>	53.6 (49.9, 57.3)	52.0 (46.3, 57.7)	55.3 (50.1, 60.3)
<b>Overweight (BMI 85-94<sup>th</sup> percentile)</b>	19.9 (17.1, 23.0)	19.6 (15.5, 24.5)	20.1 (16.5, 24.3)
<b>Obesity (BMI 95<sup>th</sup> percentile)</b>	26.5 (23.5, 29.7)	28.4 (24.1, 33.1)	24.6 (20.3, 29.4)
Obesity Class I ( 95 <sup>th</sup> percentile to <120% of the 95 <sup>th</sup> percentile)	16.8 (14.4, 19.5)	18.1 (14.7, 22.1)	15.4 (12.0, 19.6)
Obesity Class II ( 120% to <140% of the 95 <sup>th</sup> percentile, or BMI 35 and BMI<40)	8.0 (6.2, 10.3)	8.8 (6.4, 12.0)	7.2 (4.7, 10.7)
Obesity Class III ( 140% of the 95 <sup>th</sup> percentile or BMI 40)	1.7 (1.1, 2.6)	1.4 (0.7, 2.8)	2.0 (1.2, 3.4)
<b>Prediabetes/Diabetes</b>	16.5 (14.0, 19.3)	20.9 (16.9, 25.6)	11.8 (9.1, 15.2)
<b>Dyslipidemia</b>	23.3 (20.3, 26.6)	24.6 (20.4, 29.3)	22.0 (17.9, 26.8)
High TC ( 200mg/dl)	6.0 (4.6, 7.7)	6.2 (4.5, 8.6)	5.7 (3.7, 8.6)
High LDL ( 130mg/dl)	4.3 (3.1, 5.7)	4.0 (2.7, 6.0)	4.5 (2.9, 6.9)
High TG ( 130 mg/dL for 10-19 y and 100 mg/dL for 8-9 y)	12.2 (9.9, 14.9)	12.8 (9.7, 16.8)	11.5 (8.5, 15.4)
Low HDL (<40mg/dl)	11.1 (9.2, 13.4)	11.6 (9.0, 14.9)	10.5 (7.9, 14.0)
High TG/HDL ratio ( 2.2)	20.3 (17.4, 23.5)	21.8 (17.7, 26.4)	18.7 (15.0, 23.2)
High non-HDL ( 145 mg/dL)	7.4 (5.7, 9.5)	7.3 (5.4, 9.9)	7.5 (5.0, 10.9)
<b>Elevated blood pressure</b>	5.9 (4.4, 8.0)	8.5 (5.9, 12.0)	3.3 (1.7, 6.3)
High SBP (SBP 90 <sup>th</sup> percentile)	4.1 (2.8, 6.0)	5.8 (3.7, 8.8)	2.4 (1.1, 5.4)
High DBP (DBP 90 <sup>th</sup> percentile)	2.4 (1.5, 4.0)	3.4 (1.8, 6.1)	1.4 (0.6, 3.4)
<b>CVD risk factors</b>			
<b>0</b>	52.9 (49.5, 56.4)	47.8 (42.5, 53.2)	58.3 (53.2, 63.3)
<b>1-2</b>	36.8 (33.6, 40.1)	41.5 (36.3, 46.8)	31.9 (27.8, 36.2)
<b>3</b>	10.3 (8.4, 12.6)	10.7 (8.3, 13.7)	9.8 (7.0, 13.6)

*Prediabetes/Diabetes* is defined as fasting glucose 100 mg/dL or HbA1c 5.7%. *Dyslipidemia* is defined as having total cholesterol 200 mg/dL, LDL-c 130 mg/dL, triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds, or HDL-c <40 mg/dL. *Elevated blood pressure* is defined as SBP or DBP 90<sup>th</sup> percentile. *CVD risk factors* may range from 0-9 and are defined as the following: obesity; SBP or DBP 90<sup>th</sup> percentile; fasting glucose 100 mg/dL; HbA1c 5.7%; total cholesterol 200 mg/dL; LDL-c 130 mg/dL; triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds; HDL-c <40 mg/dL.

Adjusted Odds Ratios for cardiometabolic risk factors in boys versus girls, overall and by age groups. The Study of Latino Youth (SOL Youth)

**Table 3**

	All ages (N=1,310)	8-10 years (N=417)	11-12 years (N=314)	13-14 years (N=339)	15-16 years (N=240)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
<b>Obese Class II and III (vs. normal weight) <sup>1</sup></b>	1.22 (0.74, 2.03)	3.59 (1.44, 8.97)	1.06 (0.44, 2.57)	0.94 (0.30, 2.91)	0.60 (0.17, 2.09)
<b>Obese Class I (vs. normal weight) <sup>1</sup></b>	1.27 (0.84, 1.93)	1.81 (0.89, 3.69)	1.17 (0.50, 2.72)	1.54 (0.69, 3.44)	0.80 (0.31, 2.05)
<b>Overweight (vs. normal weight) <sup>1</sup></b>	1.07 (0.71, 1.61)	1.19 (0.62, 2.27)	0.77 (0.36, 1.67)	1.29 (0.65, 2.53)	1.24 (0.50, 3.09)
<b>Pre-diabetes/ Diabetes <sup>2</sup></b>	2.02 (1.35, 3.02)	1.61 (0.79, 3.26)	2.01 (1.01, 3.99)	2.70 (1.21, 6.01)	2.33 (0.98, 5.52)
<b>Dyslipidemia <sup>2</sup></b>	1.14 (0.80, 1.61)	0.96 (0.53, 1.76)	0.74 (0.40, 1.37)	2.01 (1.07, 3.77)	1.34 (0.64, 2.80)
High total cholesterol <sup>2</sup>	1.08 (0.60, 1.93)	0.59 (0.20, 1.71)	1.60 (0.62, 4.09)	2.52 (0.66, 9.62)	0.92 (0.22, 3.79)
High LDL <sup>2</sup>	0.88 (0.48, 1.60)	0.56 (0.21, 1.51)	2.04 (0.37, 11.24)	1.06 (0.31, 3.70)	0.56 (0.11, 2.76)
High triglycerides <sup>2</sup>	1.09 (0.69, 1.72)	0.80 (0.39, 1.64)	0.64 (0.24, 1.74)	1.69 (0.72, 3.95)	1.16 (0.45, 2.96)
Low HDL <sup>2</sup>	1.07 (0.71, 1.61)	1.27 (0.52, 3.11)	0.43 (0.20, 0.93)	1.84 (0.88, 3.84)	2.28 (0.78, 6.67)
High TG/HDL ratio <sup>2</sup>	1.17 (0.80, 1.71)	0.67 (0.35, 1.27)	0.62 (0.33, 1.14)	2.61 (1.43, 4.73)	1.44 (0.65, 3.21)
High non-HDL <sup>2</sup>	0.92 (0.54, 1.57)	0.45 (0.17, 1.21)	1.38 (0.46, 4.12)	2.09 (0.72, 6.05)	0.43 (0.11, 1.61)
<b>Elevated blood pressure <sup>2</sup></b>	2.68 (1.17, 6.16)	-	-	-	-
Elevated SBP <sup>2</sup>	2.41 (0.89, 6.56)	-	-	-	-



	All ages (N=1,310)	8-10 years (N=417)	11-12 years (N=314)	13-14 years (N=339)	15-16 years (N=240)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Elevated DBP <sup>2</sup> ‡	2.35 (0.78, 7.08)	-	-	-	-
CVD risk factors ( 3 vs. 0) <sup>1</sup>	1.14 (0.82, 2.26)	1.64 (0.70, 3.85)	0.97 (0.37, 2.53)	1.75 (0.66, 4.67)	1.10 (0.37, 3.27)
CVD risk factors (1-2 vs. 0) <sup>1</sup>	1.63 (1.18, 2.25)	1.70 (1.05, 2.76)	1.47 (0.78, 2.75)	2.46 (1.35, 4.49)	1.47 (0.71, 3.07)

<sup>1</sup> is adjusted for age, nativity, household income, parental education, and field center

<sup>2</sup> is additionally adjusted for age- sex- specific BMI percentile

*Prediabetes/Diabetes* is defined as fasting glucose 100 mg/dL or HbA1c 5.7%. *Dyslipidemia* is defined as having total cholesterol 200 mg/dL, LDL-c 130 mg/dL, triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds, or HDL-c <40 mg/dL. *Elevated blood pressure* is defined as SBP or DBP 90<sup>th</sup> percentile. *CVD risk factors* may range from 0-9 and are defined as the following: obesity; SBP or DBP 90<sup>th</sup> percentile; fasting glucose 100 mg/dL; HbA1c 5.7%; total cholesterol 200 mg/dL; LDL-c 130 mg/dL, triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds; HDL-c <40 mg/dL.

<sup>‡</sup>Because of low numbers stratified analyses by age group could not be estimated.

**Table 4**

Adjusted Odds Ratios for cardiometabolic risk factors in boys versus girls by weight categories. The Study of Latino Youth (SOL Youth)

	Normal weight (N=666)	Overweight (N=276)	Class I Obesity (N=236)	Class II/III Obesity (N=132)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
<b>Pre-diabetes/Diabetes</b>	2.93 (1.65, 5.20)	1.73 (0.77, 3.93)	0.98 (0.42, 2.72)	2.17 (0.74, 6.42)
<b>Dyslipidemia</b>	1.10 (0.62, 1.94)	1.13 (0.54, 2.33)	1.09 (0.57, 2.09)	1.20 (0.47, 3.09)
High total cholesterol	0.64 (0.27, 1.54)	3.34 (0.96, 11.57)	0.65 (0.18, 2.30)	5.59 (0.49, 64.05)
High LDL	0.16 (0.05, 0.54)	3.04 (0.80, 11.52)	0.94 (0.30, 2.95)	6.01 (0.51, 71.34)
High triglycerides	1.37 (0.52, 3.62)	0.70 (0.26, 1.89)	1.02 (0.48, 2.17)	1.34 (0.48, 3.68)
Low HDL	1.14 (0.50, 2.58)	1.28 (0.57, 2.86)	1.22 (0.59, 2.49)	0.66 (0.26, 1.69)
High TG/HDL ratio	1.00 (0.51, 1.99)	0.90 (0.43, 1.89)	1.64 (0.83, 3.23)	0.89 (0.32, 2.48)
High non-HDL	0.21 (0.07, 0.63)	2.83 (0.88, 9.04)	0.56 (0.22, 1.44)	2.39 (0.59, 9.62)
<b>CVD risk factors ( 3 vs. 0)</b>	0.15 (0.02, 1.09)	7.19 (1.57, 32.91)	1.23 (0.34, 4.52)	3.98 (0.71, 22.29)
<b>CVD risk factors (1-2 vs. 0)</b>	2.26 (1.39, 3.67)	1.05 (0.55, 1.99)	1.97 (0.97, 4.02)	1.25 (0.47, 3.32)

All models are adjusted for age, nativity, household income, parental education, and field center

*Prediabetes/Diabetes* is defined as fasting glucose  $\geq 100$  mg/dL or HbA1c  $\geq 5.7\%$ . *Dyslipidemia* is defined as having total cholesterol  $\geq 200$  mg/dL, LDL-c  $\geq 130$  mg/dL, triglycerides  $\geq 100$  mg/dL for 8-9 year-olds and  $\geq 130$  mg/dL for 10-16 year-olds, or HDL-c  $< 40$  mg/dL. *CVD risk factors* may range from 0-8 and are defined as the following: SBP or DBP  $\geq 90^{\text{th}}$  percentile; fasting glucose  $\geq 100$  mg/dL; HbA1c  $\geq 5.7\%$ ; total cholesterol  $\geq 200$  mg/dL; LDL-c  $\geq 130$  mg/dL; triglycerides  $\geq 100$  mg/dL for 8-9 year-olds and  $\geq 130$  mg/dL for 10-16 year-olds; HDL-c  $< 40$  mg/dL.

**Table 5**

Adjusted Odds Ratios for cardiometabolic risk factors in boys versus girls, adjusted for pubertal development (N=898)

	All ages (N=898) Unadjusted for Tanner Stage	All ages (N=898)	8-10 years (N=216)	11-12 years (N=215)	13-14 years (N=267)	15-16 years (N=200)
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Obese Class II and III (vs. normal weight) / <sup>‡</sup>	1.23 (0.67, 2.24)	1.38 (0.73, 2.60)	4.00 (0.91, 17.50)	0.82 (0.27, 2.45)	2.11 (0.66, 6.73)	-
Obese Class I (vs. normal weight) / <sup>‡</sup>	1.03 (0.61, 1.74)	1.11 (0.65, 1.88)	0.74 (0.24, 2.26)	0.78 (0.31, 2.01)	2.29 (0.92, 5.73)	-
Overweight (vs. normal weight) /	1.13 (0.72, 1.77)	1.29 (0.83, 2.00)	1.16 (0.49, 2.76)	1.66 (0.69, 3.99)	1.44 (0.68, 3.07)	1.72 (0.65, 4.59)
Pre-diabetes/ Diabetes <sup>2</sup>	2.16 (1.38, 3.39)	2.28 (1.43, 3.63)	1.48 (0.61, 3.61)	2.18 (1.02, 4.66)	2.63 (1.10, 6.25)	4.67 (1.49, 14.70)
Dyslipidemia <sup>2</sup>	1.41 (0.90, 2.20)	1.29 (0.83, 2.02)	1.18 (0.53, 2.65)	0.39 (0.17, 0.91)	2.09 (0.96, 4.56)	2.90 (0.82, 10.24)
High total cholesterol <sup>2</sup>	1.26 (0.62, 2.53)	1.22 (0.59, 2.51)	0.60 (0.14, 2.59)	1.63 (0.51, 5.17)	10.00 (1.99, 50.26)	0.67 (0.18, 2.49)
High LDL <sup>2</sup>	0.92 (0.45, 1.88)	0.83 (0.41, 1.68)	0.99 (0.27, 3.68)	1.48 (0.37, 5.93)	1.38 (0.37, 5.07)	0.35 (0.12, 1.07)
High triglycerides	1.29 (0.70, 2.38)	1.19 (0.64, 2.21)	0.62 (0.21, 1.82)	0.39 (0.11, 1.39)	1.44 (0.47, 4.47)	3.64 (0.67, 19.90)
Low HDL <sup>2</sup>	1.13 (0.69, 1.85)	1.02 (0.62, 1.68)	1.69 (0.53, 5.43)	0.20 (0.08, 0.51)	1.50 (0.62, 3.66)	3.47 (0.91, 13.33)
High TG/HDL ratio <sup>2</sup>	1.39 (0.86, 2.23)	1.23 (0.76, 1.99)	0.56 (0.21, 1.48)	0.21 (0.08, 0.61)	2.98 (1.48, 6.03)	2.64 (0.66, 10.57)
High non-HDL <sup>2</sup>	0.98 (0.49, 1.96)	0.98 (0.48, 1.97)	0.62 (0.17, 2.25)	1.05 (0.26, 4.25)	3.73 (1.02, 13.65)	0.21 (0.04, 1.12)
Elevated blood pressure <sup>2</sup>	3.63 (1.45, 9.06)	4.10 (1.63, 10.33)	-	-	-	-
CVD risk factors ( 3 vs. 0) /	1.18 (0.66, 2.11)	1.23 (0.69, 2.16)	1.07 (0.36, 3.16)	0.41 (0.12, 1.38)	2.07 (0.73, 5.88)	3.89 (0.94, 16.12)
CVD risk (1-2 vs. 0) /	1.82 (1.24, 2.67)	1.95 (1.32, 2.88)	0.96 (0.46, 2.02)	1.36 (0.65, 2.85)	3.76 (1.89, 7.49)	3.49 (1.45, 8.40)

<sup>‡</sup> is adjusted for age, nativity, household income, parental education, field center, and Tanner stage; odds ratios obtained using multinomial logistic regression

<sup>2</sup> is additionally adjusted for age- sex- specific BMI percentile; odds ratios obtained using logistic regression

*Prediabetes/Diabetes* is defined as fasting glucose 100 mg/dL or HbA1c 5.7%. *Dyslipidemia* is defined as having total cholesterol 200 mg/dL, LDL-c 130 mg/dL, triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds, or HDL-c <40 mg/dL. *Elevated blood pressure* is defined as SBP or DBP 90<sup>th</sup> percentile. *CVD risk factors* may range from 0-9 and are defined as the following: obesity; SBP or DBP 90<sup>th</sup> percentile; fasting glucose 100 mg/dL; HbA1c 5.7%; total cholesterol 200 mg/dL; LDL-c 130 mg/dL; triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds; HDL-c <40 mg/dL.

<sup>‡</sup> Because of low numbers stratified analyses by age group could not be estimated.

**Table 6**

Prevalence of cardiometabolic risk factors stratified by Mexican background

	Overall (N=1,310)	Mexican background (N=586)	Non-Mexican background (N=724)
	Weighted % (95% CI)	Weighted % (95% CI)	Weighted % (95% CI)
<b>Normal weight (BMI &lt;85<sup>th</sup> percentile)</b>	53.6 (49.9, 57.3)	54.4 (48.8, 59.8)	52.9 (48.2, 57.6)
<b>Overweight (BMI 85-94<sup>th</sup> percentile)</b>	19.9 (17.1, 23.0)	19.1 (15.5, 23.3)	20.6 (17.1, 24.5)
<b>Obesity (BMI 95<sup>th</sup> percentile)</b>	26.5 (23.5, 29.7)	26.6 (22.3, 31.3)	26.5 (22.5, 30.9)
Obesity Class I ( 95 <sup>th</sup> percentile to <120% of the 95 <sup>th</sup> percentile)	16.8 (14.4, 19.5)	17.7 (14.2, 21.8)	16.1 (12.9, 19.8)
Obesity Class II ( 120% to <140% of the 95 <sup>th</sup> percentile, or BMI 35 and BMI<40)	8.0 (6.2, 10.3)	7.3 (4.7, 11.2)	8.6 (6.4, 11.5)
Obesity Class III ( 140% of the 95 <sup>th</sup> percentile or BMI 40)	1.7 (1.1, 2.6)	1.5 (0.8, 2.9)	1.8 (1.0, 3.3)
<b>Prediabetes/Diabetes</b>	16.5 (14.0, 19.3)	15.8 (12.4, 20.0)	17.1 (13.7, 21.2)
<b>Dyslipidemia</b>	23.3 (20.3, 26.6)	24.0 (19.5, 29.2)	22.7 (19.0, 26.9)
High TC ( 200mg/dl)	6.0 (4.6, 7.7)	5.3 (3.5, 8.2)	6.5 (4.7, 8.8)
High LDL ( 130mg/dl)	4.3 (3.1, 5.7)	2.9 (1.6, 5.2)	5.4 (3.8, 7.6)
High TG ( 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds )	12.2 (9.9, 14.9)	14.0 (10.5, 18.3)	10.6 (7.9, 14.1)
Low HDL (<40mg/dl)	11.1 (9.2, 13.4)	11.7 (8.7, 15.5)	10.6 (8.2, 13.6)
High TG/HDL ratio ( 2.2)	20.3 (17.4, 23.5)	22.4 (18.3, 27.2)	18.4 (14.7, 22.8)
High non-HDL ( 145 mg/dL)	7.4 (5.7, 9.5)	7.1 (4.9, 10.3)	7.6 (5.5, 10.5)
<b>Elevated blood pressure</b>	5.9 (4.4, 8.0)	6.7 (4.2, 10.5)	5.3 (3.5, 7.9)
High SBP (SBP 90 <sup>th</sup> percentile)	4.1 (2.8, 6.0)	4.6 (2.6, 8.0)	3.8 (2.3, 6.2)
High DBP (DBP 90 <sup>th</sup> percentile)	2.4 (1.5, 4.0)	2.6 (1.2, 5.6)	2.2 (1.1, 4.2)
<b>CVD risk factors (omitting HOMA-IR)</b>			
<b>0</b>	52.9 (49.5, 56.4)	53.0 (48.3, 57.7)	52.8 (48.0, 57.6)
<b>1-2</b>	36.8 (33.6, 40.1)	36.8 (32.1, 41.8)	36.8 (32.5, 41.3)
<b>3</b>	10.3 (8.4, 12.6)	10.2 (7.3, 13.9)	10.4 (7.9, 13.5)

*Prediabetes/Diabetes* is defined as fasting glucose 100 mg/dL or HbA1c 5.7%. *Dyslipidemia* is defined as having total cholesterol 200 mg/dL, LDL-c 130 mg/dL, triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds, or HDL-c <40 mg/dL. *Elevated blood pressure* is defined as SBP or DBP 90<sup>th</sup> percentile. *CVD risk factors* may range from 0-9 and are defined as the following: obesity; SBP or DBP 90<sup>th</sup> percentile; fasting glucose 100 mg/dL; HbA1c 5.7%; total cholesterol 200 mg/dL; LDL-c 130 mg/dL; triglycerides 100 mg/dL for 8-9 year-olds and 130 mg/dL for 10-16 year-olds; HDL-c <40 mg/dL.